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WPRI REPORT

The Economic Impact of Wisconsin's Renewable Portfolio Standard

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Wisconsin Policy Research Institute

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The institute is guided by a belief that competitive free markets, limited government, private initiative, and personal responsibility are essential to our democratic way of life.

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President's Notes

Tradeoffs. More often than not, public policies represent tradeoffs. It is these tradeoffs that come to divide us. More often than we would care to admit, when we side with a particular policy argument, we conveniently forget about the tradeoffs. Advocates — and there is no shortage of advocates these days — hope that we will look past the facts that underlie the tradeoffs and simply accept the legitimacy of their position. This study is about one of those policies, renewable energy, where the tradeoffs are often forgotten.

Advocates of renewable energy — energy from sources that can be replenished — base their advocacy on two grounds. First, they point to the potential to further the goal of energy independence, i.e. lowering America's reliance on Middle Eastern oil and the periodic price spikes that come with it. Second, they highlight the impact on the environment. Coal and nuclear energy plants both bear environmental risks. Renewable energy from sun, wind, switch grass, etc. seems to address both concerns.

Based on these concerns, renewable energy advocates succeeded in passing state legislation in 1998 mandating that by 2016, utilities produce at least 10 percent of their electricity from renewable energy sources. Owing to an unusual combination of the economic downturn, which dampened the use of electricity, and the utilities' development of wind farms, Wisconsin will almost surely reach that target.

This hasn't deterred the renewable energy advocates from pushing for an even higher renewable energy requirement. In the current session of the Legislature, Senator Fred Risser is sponsoring a bill that would increase the requirement from 10 percent to 25 percent by 2025. We should expect a continued push to increase the requirement from the advocates.

We wanted to understand the true cost of Wisconsin's renewable energy requirement, so we turned to the experts at the Beacon Hill Institute (BHI). Some readers will recall that it was an analysis from BHI, published by WPRI in 2009, that revealed the economic cost of a climate change bill that was steamrolling through the Legislature. That analysis was instrumental in prompting the Legislature to take a critical second look at the impact of the legislation. The bill ultimately died.

What you will find in this report is that, while the utilities are able to accommodate the renewable energy requirement, it is not without cost. The BHI analysis pegs the 2016 cost at $210 million, which will increase the cost of electricity by 2.4 percent. The report specifies exactly how this will impact jobs and incomes. Which brings us back to tradeoffs. Before any serious consideration is given to increasing the renewable energy requirement, our elected leaders should pay attention to the impact on the well-being of Wisconsin families.

George Lightbourn

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Executive Summary

In 1998, Wisconsin lawmakers decided that it would be in the best interest of residents to mandate how electricity is produced. In the 14 years that followed, numerous laws and modifications were passed, resulting in the current Renewable Portfolio Standard (RPS). By the end of 2015, 10 percent of electricity from utilities must derive from renewable sources, with small step-up provisions from 2006 to 2015.

The Beacon Hill Institute has applied its STAMP® (State Tax Analysis Modeling Program) to estimate the economic effects of these RPS mandates. The U.S. Energy Information Administration (EIA), a division of the Department of Energy, provides optimistic estimates of renewable electricity costs and capacity factors. This study bases our estimates on EIA projections and state-specific energy details. Our major findings show that RPS law:

- Cost retail electricity customers $210 million from 2008 through to 2010

- Will raise the cost of electricity by $208 million for consumers in 2016

- Will raise Wisconsin's electricity prices by 2.4 percent by 2016.

These increased energy prices will hurt Wisconsin's households and businesses and, in turn, inflict significant harm on the state economy. In 2016, the RPS will:

- Lower employment by an expected 1,780 jobs

- Reduce real disposable income by $128 million

- Decrease investment by $18 million

- Increase the average household electricity bill by $25 per year; commercial businesses by an expected $200 per year; and industrial businesses by an expected $15,460 per year.

Introduction

Wisconsin lawmakers entered the renewable energy requirement earlier than most states, by passing a law in 1998 that required 50 new megawatts of renewable energy in the following two years.[1] Since then lawmakers changed the rules numerous times, ultimately leading to the current Renewable Portfolio Standard (RPS) that requires a set percentage of electricity to come from renewable sources.[2] Currently Wisconsin's RPS requires that utilities keep their renewable energy share at or above 2010 levels. In 2015, the RPS mandate for each utility increases to 6 percent plus their average share for the years 2001, 2002 and 2003. From 2016 and onward the required renewable share is 10 percent.

Eligible renewable sources include solar, wind, biomass, landfill methane and other gases, wave and tidal power, and fuel cells. Hydropower is eligible, as long as it has a capacity of less than 60 megawatts.[3] The law allows for reductions in conventional electricity and additional technologies to count toward the RPS, such as solar water heaters or ground source heat pumps and other thermal sources of energy.[4]

Electricity providers may create and sell or transfer both Renewable Resource Credits (RRCs) and Renewable Energy Certificates (RECs). An REC is a certificate representing one megawatt hour of total renewable energy that is delivered to a retail customer with the retail sale measured at the customer's meter. Transmission and distribution losses between the provider and the customer's meter are ignored. An RRC is either an REC that exceeds a utility's minimum requirements or a certificate representing one megawatt hour of displaced conventional electricity.[5]

RRCs may be used in subsequent years; however, RECs that are not RRCs may only be used for compliance in the year that the REC was created. Only renewable generation capacity and including incremental additions at existing installations added after January 1, 2004, are eligible to generate tradable RRCs that may be used for compliance up to four years after the year in which they were created.

Utilities are allowed to pass on all "compliance costs" associated with the RPS.[6] This means that any purchase of RECs, cost of delivery, or the cost of building and maintaining renewable energy can — and likely will — be passed along to the end consumer, whether businesses or individuals. Additionally, energy displacement policies added in 2012 can be billed to the end consumer.

The Public Service Commission of Wisconsin is required to submit reports to the Wisconsin legislature and governor every other year evaluating the impact of the RPS on the rates and revenue requirements of utilities.[7] The most recent PSC report was released June 15, 2012, covering the period from 2008 through 2010.

The PSC calculated the cost of RPS renewable generation and sales for the period, and reported that it approved $1.7 billion in capital costs for projects related to the RPS since 2007, and excluded $500 million associated with plants that had not yet come online. In 2007, the RPS renewable generation cost $21.19 million above market cost, at 3.56 percent of the state total generation and renewable sales at $19.02 million above market cost, at 3.84 percent of the state total sales.[8]

The PSC reported that the percentage of renewable wind electricity sold to Wisconsin customers increased every year over the period, reaching 7.37 percent in 2010. This is well above the 2010 RPS requirement of 5.55 percent and only 2.63 percentage points below the 2016 RPS mandate.[9] The surge in renewable generation by Wisconsin utilities has three implications. First, net generation cost rose to $109 million above market costs. Second, the utilities are pulling forward RPS compliance costs, which will result in lower marginal costs in the future, leaving them with a large quantity of RCCs banked. The PSC estimates that utilities held over 9 million megawatt hours of banked RRCs at the end of 2011.[10]

To estimate the rate impact, the PSC divided these total costs by total utility revenue over the three-year period to report a 1.9 percent rate increase for generation and a 1 percent increase using sales.[11]

Unfortunately, the PSC does not report the RPS rate impact for each year. However, we utilized the same EIA revenue data and method to fill the gap. The RPS revenue increased electricity rates by a tiny 0.32 percent in 2008 using average of the sales and generation revenues from the PSC report. However, as renewable generation almost doubled over the period, the rate impact more than quintupled to 1.6 percent in 2010. The rate impact of the RPS mandate should increase in a similar proportion to increase in renewable sales in subsequent years.[12]

One could justify the higher electricity costs if the environmental benefits — in terms of reduced greenhouse gases and other emissions — outweighed the costs. However, it is arguable whether the use of renewable energy resources – especially wind and solar – significantly reduces greenhouse gas emissions. Due to their intermittency, wind and solar often require significant backup power sources that are cycled up and down to accommodate the variability in the production of wind and solar power. In addition, a recent study found that wind power may actually increase pollution and greenhouse gas emissions.[13]

Increases in electricity costs are likely to have a negative effect on the economy because economic growth is dependent upon access to reliable and affordable energy. Since electricity is an essential commodity, consumers will have limited opportunity to avoid these costs. For the poorest members of society, the cost of energy competes directly with essential purchases in the household budget, such as food, transportation and shelter.

In this paper, the Beacon Hill Institute at Suffolk University (BHI) estimates the costs of this act and its impact on the state's economy. To that end, BHI applied its STAMP® (State Tax Analysis Modeling Program) to estimate the economic effects of the state RPS mandate.[14]

Estimates and Results

Detailed local levelized energy costs provided in PSC reporting are used to estimate the effects of Wisconsin's RPS mandate on the state. The estimate represents the change that will take place in the indicated variables against the counterfactual assumption that no RPS mandate existed. The Appendix contains details of our methodology. Table 1 displays the cost estimates and economic impact of the RPS mandate in 2016, the first full year of the 10 percent requirement.

Table 1
The Cost of the 10 percent RPS Mandate on Wisconsin (2012 $)

Costs Estimates	
Total Net Cost in 2016 ($ million)	208
Total Net Cost 2013-2017 ($ million)	788
Electricity Price Increase in 2016 (cents per kilowatt hour)	0.28
Percentage Increase	2.4
Economic Indicators (2016)	
Total Employment (jobs)	(1780)
Investment ($ million)	(18)
Real Disposable Income ($ million)	(128)

The current RPS will impose an estimated cost of $208 million in 2016. Over the four year period between 2013 and 2016, the RPS will cost Wisconsin $788 million in higher electricity costs. As a result, the RPS mandate would increase electricity prices by 0.28 cents per kilowatt hour or by 2.4 percent in 2016.

The STAMP model simulation indicates that, upon full implementation, the RPS law will cause the state's ratepayers to face higher electricity prices that will increase their cost of living, which will in turn put downward pressure on households' real incomes. In 2016, according to the model, the Wisconsin economy will shed 1,780 jobs.

The forecast job losses and price increases will reduce real incomes as firms, households and governments spend more of their budgets on electricity and less on other items, such as home goods and services. In 2016, real disposable income is expected to fall by $128 million. Furthermore, net investment will fall by $18 million.

Table 2
Annual Effects of RPS on Electricity Ratepayers (2012 $)

One Year Cost (2016)	
Residential Ratepayer ($)	25
Commercial Ratepayer ($)	200
Industrial Ratepayer ($)	15,460
Total over period (2013-2017)	
Residential Ratepayer ($)	150
Commercial Ratepayer ($)	1,195
Industrial Ratepayer ($)	91,620

Table 2 shows how the RPS mandate affects the annual electricity bills of households and businesses in Wisconsin. In 2016, on average, the RPS will cost families an estimated $25 per year; commercial businesses $200 per year; and industrial businesses $15,460 per year. Between 2013 and 2016, the average residential consumer can expect to pay $150 more for electricity, while a commercial ratepayer would pay $1,195 more and the typical industrial user would pay $91,620 more.

Emissions: Life Cycle Analysis

Up to this point, we calculated the costs and economic effects of requiring more renewable energy in the state of Wisconsin. The following section conducts a life-cycle analysis of renewable energy and the total effect that the state RPS law is likely to have on Wisconsin's emissions.

The burning of fossil fuels to generate electricity produces emission of gases as waste such as carbon dioxide (CO_2), sulfur oxides (SO_x) and nitrogen oxides (NO_x). These emissions are found to negatively affect human respiratory health and the environment (SO_x and NO_x) or are said to contribute to global warming.

Many proponents of renewable energy — such as wind power, solar power and municipal solid waste — justify the higher electricity prices, and the likely negative economic effects that follow, based on the claim that these sources produce no emissions (see examples below). But this is misleading. The fuel that powers these services, such as the sun and wind, create no emissions. However the process of construction, operation and decommissioning of renewable power plants does create emissions. This presents the question:

Is renewable energy production as environmentally friendly as some proponents claim?

"Harnessing the wind is one of the cleanest, most sustainable ways to generate electricity. Wind power produces no toxic emissions and none of the heat trapping emissions that contribute to global warming."[15]
— Union of Concerned Scientists

"Wind turbines harness air currents and convert them to emissions-free power."[16]
— Union of Concerned Scientists

"As far as pollution... zip, zilch, nada... etc. Carbon dioxide pollution isn't in the vocabulary of solar energy. No emissions, greenhouse gases, etc."[17]
— "Solar Energy Facts," www.LetsBeGridFree.com

The affirmative argument is usually based on the environmental effects of the operational phase of the renewable source (that will produce electricity with no consumption of fossil fuel and no emissions), excluding the whole manufacturing phase (from the extraction to the erection of the turbine or solar panel, including the production processes and all the transportation needs) and the decommission phase. Life cycle analysis offers a framework to provide a more complete answer to the question.

Life cycle analysis is a "cradle-to-grave" approach for assessing industrial systems. It begins with the gathering of raw materials from the earth to create the product and ends at the point when all materials are returned to the earth. By including the impacts throughout the product life cycle, such analysis provides a comprehensive view of the environmental aspects of the product or process and a more accurate picture of the true environmental trade-offs in product and process selection. Table 3 on the following page displays life cycle analysis results for conventional and "renewable" sources.

Coal and gas produce significantly more emissions of all three gases than all the other technologies. Nuclear and wind produces the least emissions of the nonconventional types, with solar and biomass significantly higher due to construction and decommission for solar and production and operations for biomass. However, the construction and decommission phases of wind and solar produce non-trivial levels of emissions, with solar several factors higher than the others. Nevertheless, life cycle analysis shows that wind, nuclear, solar and biomass produce significantly less emissions than coal and gas.

However, this analysis is incomplete. It shows that wind and solar technologies derive benefits from their ability to produce electricity with no consumption of fossil fuels and subsequent pollution without adequately addressing the intermittency of these technologies. These intermittent technologies cannot be dispatched at will and, as a result, require reliable backup generation running — idling, in effect — in order to keep the voltage of the electricity grid in equilibrium. For example, if the wind dies down or blows too hard (which trips a shutdown mechanism in commercial windmills), another power source must be ramped up (or cycled) instantaneously. Therefore, new wind and solar generation plants cannot yet be expected to replace any dispatchable generation sources.

The cycling of coal and (to a much lesser extent) gas plants as backup sources cause them to run inefficiently and produce more emissions than if the intermittent technologies were not present. A recent study found that wind power could actually increase pollution and greenhouse gas emissions in areas that generate a significant portion of their electricity from coal.[18] The current life cycle analysis literature ignores this important portion of the analysis, which provides a distorted assessment of wind and solar power.

Nevertheless, even the incorporation of renewable sources does, in and of itself, produce much less emissions than conventional sources, displacing only a small amount of emissions from conventional sources. Indeed, this amount is multiplied, due to lower capacity ratings of many green energy sources and required back-up generation.

Table 3
Emissions by Source of Electricity Generation (Grams/kilowatt hour)

Phase	Emission	Coal	Gas	Wind	Nuclear	Solar	Biomass
Construction and Decomission	CO_2	2.59	2.20	6.84	2.65	31.14	0.61
	NOx	0.01	0.01	0.06	0.00	0.12	0.00
	SOx	0.06	0.05	0.02	0.00	0.14	0.00
Production and Operation	CO_2	1,022.00	437.80	0.39	1.84	0.27	58.60
	NOx	3.35	0.56	0.00	0.00	0.02	5.34
	SOx	6.70	0.27	0.00	0.01	0.00	2.40
Total	CO_2	1,024.59	440.00	7.23	4.49	31.42	59.21
	SOx	3.36	0.57	0.06	0.01	0.14	5.34
	NOx	6.76	0.32	0.02	0.01	0.14	2.40

To better judge the actual total benefit derived from switching from the current energy source portfolio to one that involves more renewable energy, as the RPS dictates in Wisconsin, the Beacon Hill Institute compared the total emissions impact according to our projections using a life cycle analysis for the various energy sources. Table 4 displays the results.

Table 4
Change in Emissions Due to the Wisconsin RPS Mandates ('000 metric tons)

Emission Gas	2016	Total 2013-2016
No Capacity Factor Differences		
Carbon Dioxide	(5,440)	(21,000)
Sulfur Oxide	(10)	(40)
Nitrogen Oxide	(28)	(111)
Capacity Factor Differences		
Carbon Dioxide	(1,740)	(6,710)
Sulfur Oxide	1	2
Nitrogen Oxide	(8)	(30)

The RPS mandates reduce emissions of CO_2 by 5.44 million metric tons in 2016, with a total reduction of 21 million tons between 2013 and 2016. If no backup capacity were required due to the intermittency issues of renewables, then the reduction would be more than three times as much, due mainly to our projection of Wisconsin's reliance on biofuels and wood waste products to cover a sizable portion of the RPS.

Conclusion

Groups with a vested interest in promoting renewable energy, and the RPS law, see the PSC's report of a three-year revenue effect of between $191 million and $210 million as "a negligible short-term rate impact."[19] While downplaying the $200 million in costs as negligible, supporters simultaneously tout the benefits of "property tax payments by wind project owners (that) total $1.2 million." The same source claimed that wind power in the state also created between 1,000 and 2,000 jobs directly and indirectly, which were unverifiable due to lack of source or methodology.[20] Regardless, that is a cost of between $30,000 and $60,000 per job, in the earliest years of the policy, when the rules were the least imposing.

At 10 percent by 2015, the Wisconsin RPS mandate is less onerous than in neighboring states of Minnesota and Illinois and matches that of Michigan. Moreover, the mandate allows for more flexible rules for hydroelectric power. As we have shown from our calculations, there will be a likely small net loss in employment, investment and income due to this policy. Though Wisconsin's losses pale in comparison to the losses that other states with stricter mandates will face, economic losses in the state as a whole are likely as residents and business see higher electricity bills.

Supporters commit the broken window fallacy. By requiring utilities to forego lower-cost sources of conventional energy, and opting to mandate high-cost "green energy," supporters of the RPS might be able to point to individual investment projects and jobs. However, the important consideration should be the net economic effects of the mandate. The jobs that will likely be lost due to higher energy costs are not as easy to identify, but they are just as important.

Electricity Generation Costs

Typically information from the U.S. Department of Energy's Energy Information Administration (EIA) is used to estimate the Levelized Energy Cost (LEC), or financial break-even cost per megawatt hour, to produce new electricity in its *Annual Energy Outlook*.[21] But in the case of Wisconsin, detailed Levelized Cost of Electricity (LCOE or levelized cost) specific to the state was supplied in the *Report on the Rate and Revenue Impacts of the Wisconsin Renewable Portfolio Standard*.[22] These LCOEs include operation and maintenance, development and transmission connections, fuel and overnight capital costs. These prices were utilized for our projections from 2013 through 2016, which is a main reason the impact of RECs does not come into play in our analysis.

Table 5 displays capacity factors for each technology. The capacity factor measures the ratio of electrical energy produced by a generating unit over a period of time to the electrical energy that could have been produced at 100 percent operation during the same period. In this case, the capacity factor measures the potential productivity of the generating technology. Solar, wind and hydroelectricity have the lowest capacity factors due to the intermittent nature of their power sources. The capacity factors utilized in this study are the average between the high and low sources.

Table 5
Average Capacity Factor of Conventional and Renewable Sources

Plant Type	Capacity Factor
Coal	0.795
Gas	0.860
Advanced Nuclear	0.900
Onshore Wind	0.269
Solar PV	0.217
Biomass	0.830
Hydroelectricity	0.514

Estimating a capacity factor for wind power is particularly challenging. Wind is not only intermittent, but its variation is unpredictable, making it impossible to dispatch to the grid with any certainty. This unique aspect of wind power argues for an actual capacity factor rating of close to zero. Nevertheless, accredited wind capacity factors have been estimated to be between 20 percent and 40 percent, which is the range used in this report.[23] The other variables that affect the capacity factor of wind are the quality and consistency of the wind and the size and technology of the wind turbines deployed. As the United States and other countries add more wind power over time, presumably the wind turbine technology will improve, but the new locations for power plants will likely have less productive wind resources.

The EIA estimates of capacity factors paint a particularly rosy view of the future cost of renewable electricity generation, particularly wind. Other forecasters and the experience of current renewable energy projects portray a less sanguine outlook.

Today wind and biomass are the largest renewable power sources and are the most likely to satisfy future RPS mandates. The most prominent issues that will affect the future availability and cost of renewable electricity resources are diminishing marginal returns and competition for scarce resources. These issues will affect wind and biomass in different ways as state RPS mandates ratchet up over the next decade.

Both wind and biomass resources face land-use issues. Conventional energy plants can be built within a space of several acres, but a wind power plant with the same nameplate capacity (not actual capacity) would require many square miles of land. According to one study, wind power would require 7,579 miles of mountain ridgeline to satisfy current state RPS mandates and a 20 percent federal mandate by 2025.[24] Mountain ridgelines produce the most promising locations for electric wind production in the eastern and far western United States.

After taking into account capacity factors, a wind power plant would need a land mass of 20 by 25 kilometers to produce the same energy as a nuclear power plant that can be situated on 500 square meters (one-quarter square kilometer).[25]

The need for large areas of land to site wind power plants will require the purchase of land by private wind developers and/or allowing wind production on public lands. In either case land acquisition/rent or public permitting processes will likely increase costs as wind power plants are built. Offshore wind is vastly more expensive than onshore wind power and suffers from the same type of permitting process faced by onshore wind power plants, as seen in the 10-year permitting process for the planned Cape Wind project off the coast of Massachusetts.

The swift expansion of wind power will also likely suffer from diminishing marginal returns as new wind capacity will be located in areas with lower and less consistent wind speeds. As a result, fewer megawatt hours of power will be produced from newly built wind projects. The new wind capacity will be developed in increasingly remote areas that will require larger investments in transmission and distribution, which will drive costs even higher.

Biomass is a more promising renewable power source. Biomass combines low incremental costs relative to other renewable technologies and reliability. Biomass is not intermittent and therefore it is distributable with a capacity factor that is competitive with conventional energy sources. Moreover, biomass plants can be located close to urban areas with high electricity demand. But biomass electricity suffers from significant land-use issues.

The expansion of biomass power plants will require huge additional sources of fuel. Wood and wood waste account for the largest source of biomass energy today. Other sources of biomass include food crops, grassy and woody plants, residues from agriculture or forestry, oil-rich algae, and the organic component of municipal and industrial wastes.[26] Biomass power plants will compete directly with other sectors (construction, paper, furniture) of the economy for wood and food products and arable land.

The competition for farm and forestry resources would not only cause biomass fuel prices to skyrocket, but also cause the prices of domestically produced food, lumber, furniture and other products to rise. The recent experience of ethanol and its role in surging corn prices can be causally linked to the recent food riots in Mexico, and also to the struggle facing international aid organizations that address hunger in places such as the Darfur region of Sudan.[27] These two examples serve as reminders of the unintended consequences of government mandates for biofuels. The lesson is clear: Biofuels compete with food production and other basic products, and distort the market.

Calculation of the Net Cost of New Renewable Electricity

To calculate the cost of renewable energy under the RPS, BHI used data from the PSC, to determine the percent increase in utility costs that Wisconsin residents and businesses would experience. This calculated percent change was then applied to calculated elasticities, as described in the STAMP modeling section.

We collected historical data on the retail electricity sales from the PSC RPS compliance reports from 2006 to 2011. The compliance memoranda contain details of the retail electricity sales, sales applicable to the RPS standard, the RPS requirement, quantity and resource mix of renewable electricity generated and number of RECs or RRCs retired that year. We used this past data to project renewable generation for 2013 to 2016 (see Table 6).

According to the PSC compliance reports, "36 [electricity providers] have achieved 2011 renewable sales levels that already appear sufficient to meet their 2015 requirements. Of the remaining 11 electric providers and one aggregator, four are very close to meeting their 2015 requirements."[29] Moreover, as noted above, utilities have banked over 9 million RRCs from past years of over compliance with the RPS. The PSC notes that some "electric providers have future RPS compliance plans that largely depend on purchasing RRCs for compliance."[30] In light of this, we assume that those providers that are not in compliance with the mandate will purchase RRCs to comply for the foreseeable future.

Next we projected the growth in renewable sources that would have taken place absent the RPS. We used an average of the EIA's projection of renewable energy sources by fuel for the Midwest Reliability Council/East area through 2016 as a proxy to grow renewable sources for Wisconsin. We used the growth rate of these projections to estimate Wisconsin's renewable generation through 2016 absent the RPS.[31]

We subtracted our baseline projection of renewable sales from the current quantity of renewable sales for each year from 2013 to 2016 to obtain our estimate of the annual increase in renewable sales induced by the RPS in megawatt hours.

To estimate the cost of producing the additional renewable energy under an RPS against the baseline, we used PSC estimates of the LCOE, or financial break-even cost per megawatt hour, to produce the electricity.[32] We used the 2010 LCOE for the years 2010 through 2016 to calculate the cost of the new renewable electricity and avoided conventional electricity, since state level projections were not available.

To determine the impact of the RPS standard in a given year, we calculated the amount of renewable energy the RPS would require that year and compared it to our renewable energy baseline sales for that year; the difference represents the renewable sales attributable to the RPS policy. We then determined which renewable energy source(s) would be used to meet the renewable energy sales attributable to the RPS and calculated the additional renewable energy costs by using the LCOE(s) for the relevant energy source(s).

The increased total costs in renewable energy lead to decreased total costs in conventional energy, since less conventional energy would be needed and sold. The decrease in conventional energy production is not as large as the increase in renewable energy production, however. Wind power and solar power in particular are intermittent (as reflected in their relatively low capacity factors), and it would still be necessary to keep backup conventional energy sources online and ready to meet any sudden electrical demands that renewable sources could not instantly provide. To estimate the share of conventional energy that would still be running as backup, we used a ratio of the renewable energy capacity factor to the conventional energy capacity factor.[33]

Table 6
Projected Electricity Sales, Renewable Sales and 10 percent RPS requirement[32]

Year	Projected Electricity Sales MWhs (000s)	Projected Renewable MWhs (000s)	RPS Sales MWhs (000s)	Difference MWhs (000s)
2013	70,375	837	6,094	5,257
2014	71,678	842	6,094	5,252
2015	73,010	845	6,094	5,249
2016	74,373	848	6,094	5,246
Total	**289,436**	**3,372**	**24,376**	**21,004**

Table 7
The Cost Case of 10 percent RPS Mandate from 2013 to 2016

Year	Gross Cost (2010 $000s)	Less Conventional (2010 $000s)	Total (2010 $000s)
2013	580,257	391,300	188,956
2014	580,257	383,146	197,111
2015	573,626	379,576	194,050
2016	615,129	407,131	207,999
Total	**2,349,268**	**1,561,153**	**788,116**

Ratepayer Effects

To calculate the effect of the RPS on electricity ratepayers, we used EIA data on the average monthly electricity consumption by type of customer: residential, commercial and industrial.[34] The monthly figures were multiplied by 12 to compute an annual figure. We inflated the 2010 figures for each year using the average annual increase in electricity sales over the entire period.[35]

We calculated an annual per-kWh increase in electricity cost by dividing the total cost increase — calculated in the section above — by the total electricity sales for each year. We multiplied the per-kWh increase in electricity costs by the annual kWh consumption for each type of ratepayer for each year. For example, we expect the average residential ratepayer to consume 9,559 kWhs of electricity in 2016 and we expect the cost scenario to raise electricity costs by 0.28 cents per kWh in the same year. Therefore we expect residential ratepayers to pay an additional $25 in 2016.

Modeling the RPS using STAMP

We simulated these changes in the STAMP model as a percentage price increase on electricity to measure the dynamic effects on the state economy. The model provides estimates of the proposal's impact on employment, wages and income. Each estimate represents the change that would take place in the indicated variable against a "baseline" assumption of the value of that variable for a specified year in the absence of the RPS policy.

Because the RPS requires Wisconsin households and firms to use more expensive "green" power than they otherwise would have under a baseline scenario, the cost of goods and services will increase under the RPS. These costs would typically manifest through higher utility bills for all sectors of the economy. For this reason we selected the sales tax as the most fitting way to assess the impact of the RPS. Standard economic theory shows that a price increase of a good or service leads to a decrease in overall consumption, and consequently a decrease in the production of that good or service. As producer output falls, the decrease in production results in a lower demand for capital and labor.

BHI utilized its STAMP (State Tax Analysis Modeling Program) model to identify the economic effects and understand how they operate through a state's economy. STAMP is a five-year dynamic computable general equilibrium model that has been programmed to simulate changes in taxes, costs (general and sector-specific) and other economic inputs. As such, it provides a mathematical description of the economic relationships among producers, households, governments and the rest of the world. It is general in the sense that it takes all the important markets, such as the capital and labor markets, and flows into account. It is an equilibrium model because it assumes that demand equals supply in every market (goods and services, labor and capital). This equilibrium is achieved by allowing prices to adjust within the model. It is computable because it can be used to generate numeric solutions to concrete policy and tax changes.[36]

In order to estimate the economic effects of a national RPS, we used a compilation of six STAMP models to garner the average effects across various state economies: New York, North Carolina, Washington, Kansas, Indiana and Pennsylvania. These models represent a wide variety in terms of geographic dispersion (Northeast, Southeast, Midwest, the Plains and the West), economic structure (industrial, high-tech, service and agricultural), and electricity sector makeup.

First we computed the percentage change to electricity prices as a result of three different possible RPS policies. We used data from the EIA from the state electricity profiles, which contain historical data from 1990-2008 for retail sales by sector (residential, commercial, industrial and transportation) in dollars and MWhs and average prices paid by each sector.[37] We inflated the sales data (dollars and MWhs) though 2016 using the historical growth rates for each sector for each year. We then calculated a price for each sector by dividing the dollar value of the retails sales by kWhs. Then we calculated a weighted average kWh price for all sectors using MWhs of electricity sales for each sector as weights. To calculate the percentage electricity price increase we divided our estimated price increase by the weighted average price for each year. For example, in 2016 for our cost case we divided our average price of 11.71 cents per kWh by our estimated price increase of 0.73 cents per kWh for a price increase of 6.3 percent.

Table 8
Elasticities for the Economic Variables

Economic Variable	Elasticity
Employment	-0.022
Investment	-0.018
Disposable Income	-0.022

Using these three different utility price increases — 1 percent, 4.5 percent and 5.25 percent — we simulated each of the six STAMP models to determine what outcome these utility price increases would have on each of the six states' economy. We then averaged the percent changes together to determine the average effect of the three utility increases. Table 8 above displays these elasticities, which were then applied to the calculated percent change in electricity costs for the state of Wisconsin discussed above.

We applied the elasticities to percentage increase in electricity price and then applied the result to Wisconsin economic variables to determine the effect of the RPS. These variables were gathered from the Bureau of Economic Analysis Regional and National Economic Accounts as well as the Bureau of Labor Statistics Current Employment Statistics.[38]

Life Cycle Analysis

For our LCA we used various studies to determine what the cradle-to-grave emissions per MWh was, taking into account construction, decommission, operation and maintenance.

For coal we reviewed three different system types, an "average system" that accounts for emissions from typical coal fired generation in 1995, New Source Performance Standards based on requirements put into effect for all plants built after 1978, and Low Emission Boiler Systems, which are newer, more efficient coal plants.[39] The LCA calculations account for various inputs including, but not limited to, mining, transportation of minerals, power plant operation as well as decommissions and disposal of a plant. Natural gas plants LCAs were based on the LCA for Gas Combined Cycle Power Generation plants, a type of plant that is similar to the majority of the natural gas plants in the United States.[40]

The LCA for wind power accounted for both onshore and offshore wind power, which has different values for manufacturing, dismantling, operation and transportation for each type. Solar photovoltaic estimates were wide ranging, but a *Science Direct* paper supplied an in-depth, comprehensive review.[42] It reviewed three different types of crystalline silicone modules as well as a CdTe thin film version and induced many different costs such as emissions from building the module and frame (for the crystalline silicone version) as well as operation and maintenance emissions. For biomass and wood waste LCA, we used a report that looked at the production of energy using wood and biomass byproducts to produce energy.[43] There different types of delivery systems (lorry, train and barge) for the fuel, as well as construction, operation and decommissioning.

With total emissions per MWh calculated, we were able to use our in-house model to calculate the total emissions that would be added to and removed from the Wisconsin energy system. The calculation used the amount of renewable energy added per the RPS law, as well as the amount of conventional power that would be removed, after accounting for capacity factor requirements to keep a constant amount of energy produced. Each MWh added was multiplied by its respective LCA emission, and then we subtracted the amount of conventional time LCA emissions. With a basic conversion from grams to metric tons, we had calculated the results seen in Table 4. An identical calculation was done, but not accounting for capacity factors.

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